W. H. Rayner

The relative importance of tropics in Surveying Instruction

THE RELATIVE IMPORTANCE OF TOPICS IN SURVEYING INSTRUCTION

BY

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UNIVERSITY OF ILLINOIS

THE GRADUATE SCHOOL

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY

SUPERVISION BY William Horace Rayner

ENTITLED The Relative Importance of Topics in Surveying Instruction

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR

THE DEGREE OF Master of Science

B R Buckingham
In Charge of Thesis

C E Chadsey
Head of Department

Recommendation concurred in*

Committee
on
Final Examination*

*Required for doctor's degree but not for master's

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I. INTRODUCTION.

The selection of the content of any curriculum is governed by two conditions: first, the value of the subject-matter (a) to the individual, and (b) to society; and second, the learning difficulty of the subjects taught.

The first of these conditions, namely, the value of the subject-matter, may be determined by different methods depending on the subject and the material. Charters[1] has listed some five or six methods. One of these which is used in this study is described by Charters as follows:

"Another method of analysis of objectives is that of selecting subject matter on the basis of the common opinion of those engaged in using practical applications. Wilson and others attempted to determine the curriculum in arithmetic by collecting the opinion of business men as to which of the operations are of greater and less use in their businesses. These studies show where, in the opinion of the business men of the community, the greatest emphasis should be placed and where eliminations and additions might occur. Such methods should be used with the greatest caution because of the difficulty of obtaining the real judgments of practical men, who, being untrained in this sort of analysis are likely to make snap judgments.

"A more careful study in this method was made by a committee of the Iowa State Teachers' Association which collected 5,036 problems in arithmetic reported upon by mature adults as having been met by them in their work. Reports were received from 457 persons, 41 percent of whom were house-keepers.

[1] Charters, W. W. "What Has Thus Far Been Accomplished and Is Now Available for the Readjustment of School Curricula." University of Illinois, Bulletin Vol. XVI. No. 12, pp. 27-30.

These problems were solved and the arithmetical processes used were tabulated and they show, among other things, that only simple operations are used and that the most frequently mentioned items were the four fundamental operations, fractions, United States money, accounts, percentage, buying and selling. It shows, also, the greatest use of these problems was made in connection with groceries, dry goods, fuel, labor, meat and clothing (probably due to the 41 percent of women reporting.)

"Camerer has determined what bankers think should be known about banking by depositers, with a view to teaching this in the schools.

"Another appeal to the cumulated opinion of individuals is made by Bagley in defining the objectives of American history.

"All such appeals to the opinions of others must be conducted with unusual care to make certain that the real opinion is being recorded. It is doubtful if one can safely use any known device less laborious than that of the oral questionnaire. That is, the questionnaire should be prepared but the answers should be recorded by the investigator himself in an interview with the one questioned. The written questionnaire upon matters of opinion has been found to be unreliable and saving in time is not justified because of the inaccuracy of the results."

The second condition mentioned above, namely, the learning difficulty of the subjects taught, has an important effect in fixing the place of the different topics of a curriculum in a rank order of importance. It should be remarked in this connection, that topics exceedingly easy or exceedingly difficult to learn are not properly included in this discussion. The effect of the condition of learning difficulty will be to elevate those topics from a lower to a higher rank which are relatively easy to learn and conversely to lower those topics from a higher to a lower rank which are relatively

difficult to learn. Before this can be done, however, the relative values of the topics must be determined and it is this step only, in the procedure with which this study is concerned.

II. STATEMENT OF THE PROBLEM.

This study has for its purpose the determination of the relative value of topics which compose the subject-matter of elementary courses in surveying.

III. PROCEDURE.

It will be noticed that Charters has indicated the danger in determining the opinions of individuals by the use of the written questionnaire. This danger cannot be denied where there is difficulty in establishing the exact point of view from which a judgment is made, and in making clear the idea on which a judgment is desired. This study, it is believed, has overcome this danger in two ways: first, the subject-matter is definite and is expressed in well standardized terms concerning which there is small chance for ambiguity or confusion; second, the point of view, "on the basis of my experience only," can be subject to but little misinterpretation in the case of practising engineers. In the case of teachers where experience might include both practise of surveying and practise of teaching, the results show a consistency as great as, or even greater than that of the former group.

Since the subject-matter of surveying is well systematized in text-books and field-manuals for students and practising surveyors, a large number of the topics to be avaluated, have been secured from this source; the author's own experience provided some additional material; and finally a few topics were added on the suggestion of practising engineers and teachers who answered a preliminary questionnaire, to be described later.

The selection of the topics to be compared, was made by the guidance of the following principles: first, only those topics were included, which were

deemed important enough to justify the use of an hour's time in the classroom or field; second, the statements were made to be mutually exclusive in so far as possible; third, both the field and office practice of the surveyor were considered at all times; and fourth, only those topics were included which are fundamental to all branches of surveying practice.

According to these principles, the following text-books were carefully analyzed in listing the separate topics; "Principles of Surveying", by Breed and Hosmer; "Plane Surveying", by John Tracy; "Theory and Practice of Surveying", by Johnson and Smith; "Plane Surveying", by Raymond; "Manual of Surveying for Field and Office", by Davis; "Surveying Manual", by Pence and Ketchum. This analysis, including the author's experience yielded about one hundred and forty topics.

It was immediately evident that this number of topics could not be compared by each man addressed, and it would be necessary to make a division. This was done by classifying the topics according to the different instruments used in surveying work. An inspection of this classification showed that about one-half of the topics related to the transit and tape and the remainder related to the level, plane-table, miscellaneous instruments, and computations. Therefore, this division was used and these two sets of topics were sent out in separate letters, an equal number of each, to be judged by practicing engineers and teachers.

A preliminary trial was made to answer these questions:

1. What proportion of engineers and teachers addressed, will reply?
2. Will the recipients rank the individual topics or will they group them only in five groups?
3. Have any important topics been omitted?

Forty-two letters were mailed out in this preliminary trial and seven-

teen replies were received which indicated that replies might be expected from about forty percent of persons addressed. Twelve individuals ranked each separate topic and five grouped them in the five groups only. This condition indicated clearly that if so large a percent were willing to rank the individual topics, it would be well worth while to insure that much additional care in making the comparisons by including that provision in the final form of the questionnaire.

Three topics only, were added to the original list as a result of the request for suggestions of important topics which had been omitted.

In order to reduce the effort involved on the part of the recipient and to insure as careful ranking as possible, the following arrangement of the questionnaire was devised.

UNIVERSITY OF ILLINOIS
Civil Engineering Department.

103 Engineering Hall,
Urbana, Illinois.

Dear Sir:

The Civil Engineering Department of the University of Illinois is interested to know what subject matter, i. e., what theory, field and office work should be given to students in surveying. Accordingly this department is seeking the co-operation of a large number of teachers and practising engineers and surveyors, of which you are one, to furnish us the benefit of your experience and advice. We shall deem it as a distinct favor if you will kindly devote the necessary time, perhaps an hour, to help us solve this important problem.

You will be asked to compare a number of topics pertaining to surveying work as regards their relative importance in courses in surveying. In comparing these topics "Importance" is to be judged on the basis of YOUR EXPERIENCE ONLY.

Enclosed you will find slips of paper on which are printed statements of the topics which pertain to the level, plane-table, and computations.[12] The same statements are also printed on whole sheets to facilitate comparison In making your comparisons will you kindly follow these directions:

1. Read the statements on each sheet through carefully, so as to become acquainted with the character and range of the topics.

2. Group the slips in five groups under the headings printed on the five colored slips, which you will find enclosed and marked as follows; A highest value; B next to highest value; C middle value; D next to lowest value; and E lowest value.
N.B. Please do not place more than 20 topics in any single group.

3. Rank the slips in each group by numbering the most important topic in that group as #1, the next important topic #2, etc. If there are two or more topics which you judge to be of equal importance, mark each of these with the same rank number.

4. Assemble the slips in each of the five bundles with its proper colored slip.

5. Fill out the enclosed information blank and mail together with the slips to the Department of Civil Engineering, University of Illinois, Urbana, Illinois.

I am,

Very sincerely yours,
W. H. Rayner
Assistant Professor of Surveying.

[12] In the parallel set, this sentence read "transit and tape."

1001 How to measure a vertical angle. (field)

1002 How to make a compass survey of a field for area. (field)

1003 How to take a magnetic bearing. (field)

1004 How to survey, with a tape only, a field with a curved boundary. (field)

1005 How to stake out a bridge. (field)

1006 How to stake out a building. (field)

1007 How to locate established lot corners. (field)

1008 How to relocate lost corners.

1009 How to stake out a simple circular curve. (field)

1010 How to stake out a vertical curve. (field)

1011 The student should be given a thorough drill in the details of the construction of the transit; accompanied if practicable by inspecting the various parts.

1012 How to determine the probable error in sigthing a flagpole at different distances. (field)

1013 The student should be given practise in pacing distances.

1014 The student should be made to thoroughly understand the function of the various parts of the engineer's TELESCOPE, i. e., objective lens, cross-hairs, and eye-piece.

1015 How to rerun an old survey from a deed.

1016 How to make a survey of a field for a deed. (field)

1017 How to determine a true meridian by an observation on polaris at ELONGATION. (field)

1018 How to determine the stadia constants in the field.

1019 The student should be given a working knowledge only, of the stadia formulas.

1020 The student should be taught how to derive the stadia formulas.

1021 How to stake out sewer lines and grades. (field)

1022 The student should be given instruction in the proper handling and care of the instrument to protect it from injury. (does not refer to adjustments.)

1023 How to set a transit at a point C which shall be on a straight line between two established points A and B which are not intervisible. (field)

1024 How to sub-divide regular and irregular sections of land.

1025 How to rerun established street lines. (field)

1026 How to stake out new lot lines.

1027 The student should be taught the sources and magnitude of the errors in stadia measurements.

1028 The student should be taught the sources and magnitude of errors in tape measurements.

1029 How to eliminate errors in tape measurements.

1030 How to correct a bearing for change in the declination of the needle.

1031 How to determine the declination of the needle. (field)

1032 How to keep transit notes. (field)

1033 How to measure distances, with tape only, past obstructions. (field)

1034 How to carry a transit line past an obstruction. (field)

1035 How to survey a field with a tape only. (field)

1036 The student should be taught the amount of error in transit work due to inaccurate setting over a point.

1037 How to adjust a compass-needle and pivot point. (field)

1038 How to lay off an angle by repetition. (field)

1039 How to prolong a line by the method of double sights. (field)

1040 How to Meander a stream.

1041 How to stake out a new city sub-division. (field)

1042 How to determine a true meridian by direct observation with a transit on the sun. (field)

1043 The student should be taught what the judicial functions of a surveyor are in connection with land surveys.

1044 How to measure an angle by repetition. (field)

1045 How to determine the magnifying power of any telescope. (field)

1046 How to measure the height of a tower. (field)

1047 How to determine a true meridian by an observation on polaris AT ANY TIME. (field)

1048 The student should be taught the theory and use of the solar attachment to a transit. (field)

1049 How to eliminate the errors due to eccentricity in the verniers of a transit.

1050 How to run a random line with a transit. (field)

1051 How to run an azimuth traverse. (field)

1052 How to make the adjustments of a transit. (field)

1053 How to run an interior angle traverse. (field)

1054 The student should be taught what checks may be applied to a transit traverse. (field)

1055 The student should be taught what angular errors of closure may be expected in running a transit traverse.

1056 The student should be taught just what effect each instrumental error due to bad adjustments in a transit, has on the various kinds of transit work.

1057 The student should be taught how to measure angles and erect perpendiculars with the tape. (field)

1058 How to run a deflection angle traverse. (field)

1059 How to measure the angle between two intersecting lines with a transit. (field)

1060 How to locate details with a transit and tape. (field)

1061 Take slope measurements in the field and reduce to the horizontal.

1062 How to read and determine the least count of any vernier. (field)

1063 How to compute bearings from angles and vice versa.

1064 How to use the transit when out of adjustment so as to eliminate errors.

1065 The student should be taught the common mistakes and errors are, in compass work.

1066 How to keep notes for transit-stadia work.

1067 How to stake out tile-drainage-ditch line and grades.

1068 How to stake out open-drainage-ditch line and grades.

1069 How to detect local attraction and to adjust a compass traverse.

A

On the basis of MY EXPERIENCE I judge the topics printed on the accompanying slips to be of the HIGHEST value in courses in Surveying.

B

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of NEXT TO HIGHEST value in courses in Surveying.

C

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of MIDDLE value in courses in Surveying.

D

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of NEXT TO LOWEST value in courses in Surveying.

E

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of LOWEST value in courses in Surveying.

2001 How to make the adjustments of the plane-table alidade. (field)

2002 The student should understand clearly the effect on computed results of using the trigonometric functions of small angles.

2003 How to determine differences in elevation by trigonometric leveling; i. e., by measured distances and a vertical angle. (field)

2004 How to compute cross-section areas.

2005 The student should be made familiar with the construction of the aneroid barometer.

2006 The student should be made familiar with the constructoin of the mercurial barometer.

2007 The student should be given practise in the computation of irregular areas; e. g., trapezoids, and areas with curved boundaries.

2008 The student should be made thoroughly familiar with the degree of *accuracy* that may be expected in level circuits.

2009 The student should be given some practise in measuring slopes and elevations with the clinometer. (field)

2010 The student should be thoroughly drilled in the various checks to be applied to computations.

2011 How to compute areas by the method of coordinates.

1012 The student should be given a thorough drill in the systematic arrangement of computations.

2014 The student should be taught some of the common short cuts in computations.

2015 The student should be made to understand how many figures are significant and should be retained in computations.

2016 The student should be carefully advised regarding the advantages and limitations of slide-rule computations.

2017 How to set grade-stakes for railway, highway, street, sewer, or sidewalk construction. (field)

2018 How to compute areas by the method of latitudes and departures.

2019 How to plot a traverse by the method of total latitudes and departures.

2020 The student should determine the probable error of a single reading of a rod at various distances. (field)

2201 How to eliminate the various errors in leveling; e.g., keep the lengths of backsights and fore-sights equal. etc.

2022 How to part-off a given area from a field.

2023 The student should be well practised in making conventional signs for maps; such as, railways, highways, trees, grass, water-lines, contours, etc.

2024 The student should be made familiar with the details of construction of the plane-table instrument.

2025 The student should be well practise n lettering.

2026 The student should be made to understand the sources and magnitude of errors in barometric leveling.

2027 The student should be made thoroughly familiar with the details of construction of the engineer's *dumpy* level.

2028 How to make the adjustments of the dumpy level. (field)

2029 The student should be given practise in running levels with the *hand level*.

2030 How to run a line of profile-levels. (field)

2031 How to correct for the curvature of the earth for unequal sights in leveling.

2032 How to keep the notes for transit-stadia levels.

2033 How to run a line of transit stadia levels. (field)

2034 The student should be made thoroughly familiar with the details of construction of the engineer's *wye* level.

2035 How to make the adjustments of the wye level (not peg method). (field)

2036 How to run a "double rodded" line. (field)

2037 The student should be given a thorough understanding of the methods used in laying out the U. S. Public lands; including guide meridians, correction parallels, township exteriors and section lines.

2038 The student should be taught when it is advisable to use logarithms.

2039 How to plot details on a map.

2040 How to locate contour points on the plane-table map. (field)

2041 How to estimate earth-work from contour maps.

2042 The student should be given some drill in composing, arranging, and executing titles for drawings and maps.

2043 The student should receive practise in drawing in contours on a plane-table map. (field)

2044 The student should be taught how the various kinds of corners in land surveys are marked.

2045 How to plot a traverse by the "chord" method.

2046 How to plot a traverse by the "tangent" method.

2047 How to keep cross-section notes. (field)

2048 How to keep profile level notes. (field)

2049 The student should be given practise in reproducing maps with the pantograph.

2050 The student should be given practise in determining areas with the planimeter.

2051 The student should be taught the advantages and limitations of the planimeter.

2052 How to perform the plane-table solution of the two-point problem. (field)

2053 How to perform at least one plane-table solution of the three-point problem. (field)

2054 The student should be given practise in making preliminary estimates of earth work from profiles.

2055 How to plot details on a profile.

2056 The student should be made thoroughly familiar with the simplest methods of computing earth-work quantities.

2057 The student should be made to understand clearly the *amount* of the various errors in leveling; such as, curvature of the earth, bubble not in center of tube, etc.

2058 How to level across a wide river or ravine. (field)

2059 How to locate points on the plane-table by the methods of intersection and resection. (field)

2060 The student should be made familiar with the details of construction of the various kinds of level rods.

2061 The student should be made familiar with the principles and construction of the sextant.

2062 How to read horizontal and vertical angles with a sextant. (field)

2063 How to use and interpret various map scales.

2064 How to supply "missing data" in a survey; i.e., the bearing or distance of one side, etc.

2065 How to run a plane-table traverse. (field)

2066 The student should be made familiar with the various checks that my be applied to plotted traverses.

2067 How to determine the angular value of one division of a level tube. (field)

2068 How to set slope stakes and take cross-sections for earth work. (field)

2069 The student should understand clearly the regulations that exist between measured angles and measured distances to secure consistent accuracy in field work.

2070 How to determine the probable error of a series of measurements.

2071 How to use the level when out of adjustment, so as to eliminate errors

INFORMATION BLANK

Name______________________________Date____________________

Present Position____

Business Address____

Technical Education____

College Course

Professional Experience: Please indicate below the number of years spent (a) in connection with actual surveying work and (b) in general engineering practice in one or more of the fields indicated.

1. Railroad surveys________________yrs.
2. General railroad work________________yrs.
3. City surveys________________yrs.
4. General city work________________yrs.
5. Highway surveys________________yrs.
6. General highway work________________yrs.
7. Drainage surveys________________yrs.
8. General drainage work________________yrs.
9. Land surveys________________yrs.
10. Miscellaneous surveys________________yrs.
11. Total number of calender years in the practice of surveying________________yrs.

From the tendencies indicated in the preliminary trial it seemed that some real conclusions could be based on two hundred replies, which indicated that the scope of the investigation should include some six hundred names.

The mailing list was made up of six hundred and ten names, four hundred and seventy practising engineers, and one hundred and forty teachers. The names were selected from the year books of the following societies: Society for the Promotion of Engineering Education; Illinois Society of Engineers; Colorado Society of Engineers; Connecticut Society of Civil Engineers; Iowa Engineering Society; Ohio Engineering Society; Kansas Engineering Society; Florida Engineering Society; Louisiana Engineering Society; American Society of Civil Engineers.

These lists were chosen to insure a wide geographical distribution even though it is well known that men in the profession of civil engineering are sure to represent experience gained in many quarters of the land.

The titles of the men in the various societies showed that the branches of civil engineering most frequently represented were the following: railway, city, land surveys, drainage, highway, and miscellaneous. A count was then made of the number of names belonging to each classification. The final list of names was then composed of a proper proportion from each class in an attempt to give each class its proper weight in a composite judgment of all concerned. The information blank provided for a record of the duration of each man's experience in each branch, and the data secured is recorded below.

IV. DATA.

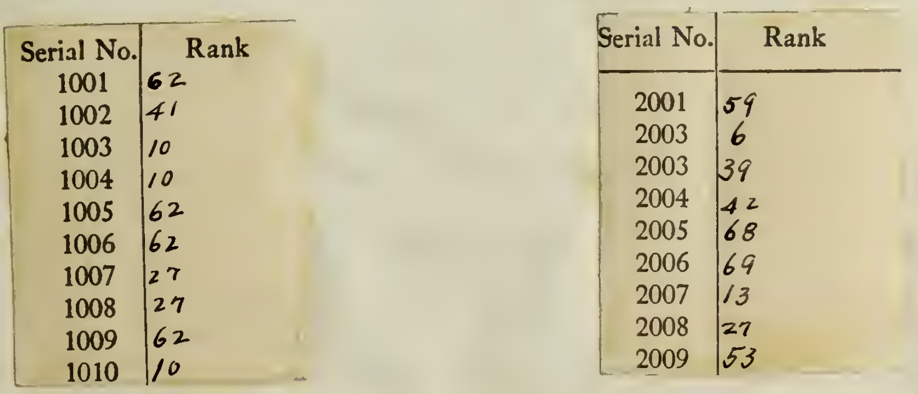
1. NUMBER OF REPLIES: One hundred ninety-nine persons returned the slips properly arranged. One hundred and one of whom ranked the topics relating to the transit and tape, (serial numbers 1001 to 1069) and ninety-eight of whom ranked the topics relating to the level, plane-table, computa-

tions, etc., (serial numbers 2001 to 2071). These sets of ranked topics together with the facts on the Information Blanks constitute the data for this study.

2. RECORD SLIPS: The rank order of the slips from each person was recorded on card-board slips. The blanks at the bottom of which were used to record the facts on the Information Blank. These data show in the case of Mr. Rudolph (p15) that he attended the Sheffield Scientific School at Yale; his practice has included forty-nine years in city surveys; forty-nine years in land surveys, and represents a total practice of forty-nine calender years. The words "Rank" and "Group" indicate whether the topics had been ranked individually according to direction No. 3 of the letter of instructions, (p. 6.) or whether the topics had been grouped only in the five groups. In the former case each topic represented by its serial number was given a different rank number, beginning with the most important topic as #1 and the least important topic #69 in one series and #71 in the other. In the case of the "grouped" arrangements, each topic in each group was given the same rank number; namely, that number which the middle topic for that group would have received in a continuous individual ranking. A sample record slip for each case is shown below.

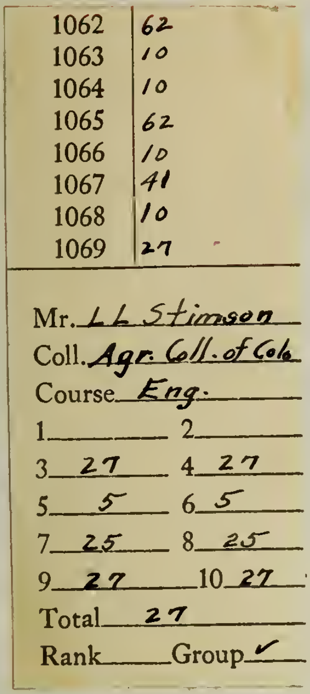
2. RECORD SLIPS:

FIG. I.



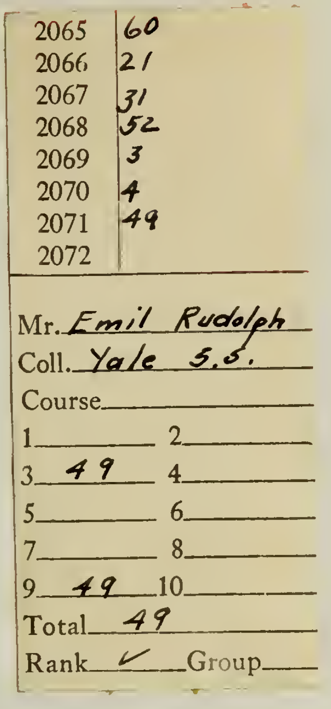
Serial No.	Rank
1001	62
1002	41
1003	10
1004	10
1005	62
1006	62
1007	27
1008	27
1009	62
1010	10

Serial No.	Rank
2001	59
2003	6
2003	39
2004	42
2005	68
2006	69
2007	13
2008	27
2009	53



1062	62
1063	10
1064	10
1065	62
1066	10
1067	41
1068	10
1069	27

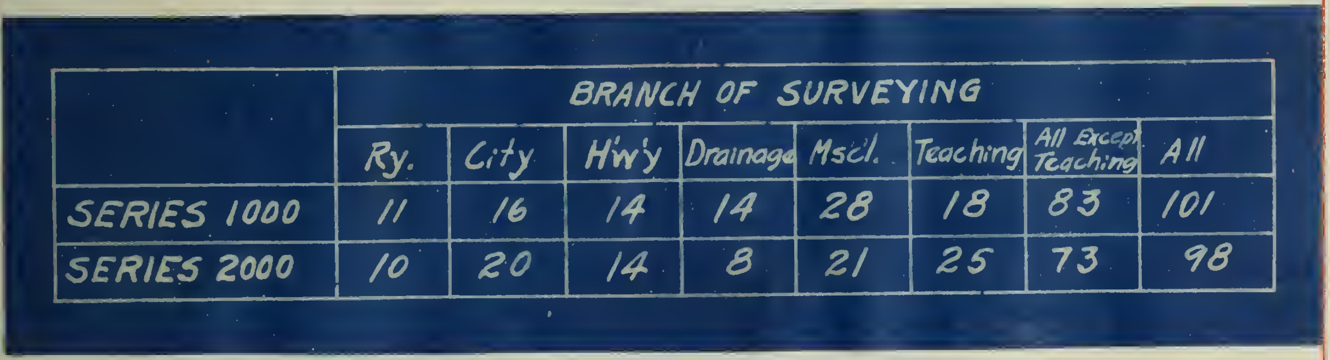
Mr. L L Stimson
Coll. Agr. Coll. of Colo
Course Eng.
1 ____ 2 ____
3 27 4 27
5 5 6 5
7 25 8 25
9 27 10 27
Total 27
Rank ____ Group ✓



2065	60
2066	21
2067	31
2068	52
2069	3
2070	4
2071	49
2072	

Mr. Emil Rudolph
Coll. Yale S.S.
Course ____
1 ____ 2 ____
3 49 4 ____
5 ____ 6 ____
7 ____ 8 ____
9 49 10 ____
Total 49
Rank ✓ Group ____

3. <u>BRANCHES OF SURVEYING:</u> The record slips having been filled out, were then assembled in twelve bundles according to the different branches of surveying in which the men were mainly employed. The numbers belonging in the various branches were found to be as follows:



	BRANCH OF SURVEYING							
	Ry.	City	H'w'y	Drainage	Mscl.	Teaching	All Except Teaching	All
SERIES 1000	11	16	14	14	28	18	83	101
SERIES 2000	10	20	14	8	21	25	73	98

The information which formed the basis for this grouping was (a) the title given by the men on the information blank, and (b) if this was not a clear indication, the slip was included in that branch to which it seemed to belong according to the years of service in the various branches. It was found impracticable to make a group for land surveyors on account of the fact that very few men class themselves as such. This branch is best represented in the "Miscellaneous" branch, which includes all county surveyors, land surveyors

TABLE I.

Showing Average Rank of Topics as Computed from Score-Slips. All Branches except Teaching.

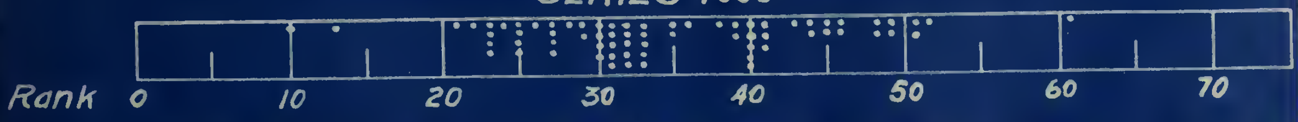
SERIES 1000					
Topic	Rank	Topic	Rank	Topic	Rank
1001	31	1026	31	1051	33
2	45	27	39	52	13
3	33	28	29	53	39
4	49	29	25	54	33
5	27	1030	46	55	33
6	31	31	41	56	30
7	28	32	10	57	41
8	23	33	35	58	31
9	21	34	24	59	23
1010	27	35	44	1060	27
11	32	36	35	61	36
12	49	37	52	62	40
13	40	38	40	63	26
14	32	39	25	64	33
15	25	1040	38	65	48
16	23	41	32	66	29
17	40	42	40	67	32
18	45	43	30	68	31
19	43	44	32	69	51
1020	48	45	61	1070	
21	23	46	51	71	
22	30	47	41	72	
23	22	48	46	73	
24	27	49	44	74	
25	25	1050	30	75	

SERIES 2000					
Topic	Rank	Topic	Rank	Topic	Rank
2001	50	2026	57	2051	39
2	36	27	39	52	54
3	34	28	30	53	52
4	17	29	41	54	23
5	57	2030	9	55	23
6	60	31	47	56	15
7	20	32	27	57	36
8	28	33	25	58	39
9	53	34	26	59	47
2010	21	35	20	2060	47
11	37	36	48	61	58
12	22	37	27	62	57
13		38	39	63	30
14	33	39	22	64	32
15	31	2040	44	65	41
16	35	41	29	66	35
17	12	42	35	67	52
18	25	43	44	68	14
19	27	44	34	69	27
2020	42	45	42	2070	41
21	20	46	36	71	29
22	39	47	12	72	
23	32	48	12	73	
24	47	49	51	74	
25	22	2050	37	75	

DIAGRAM I.

Showing Distribution of Data in Table I.

SERIES 1000



SERIES 2000

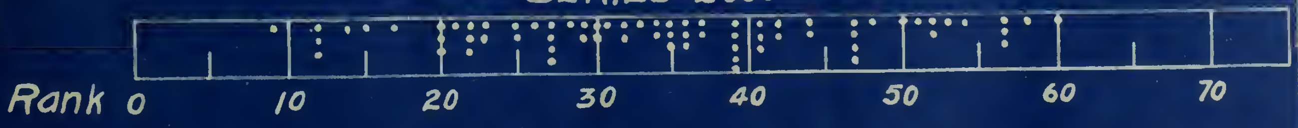


TABLE II.

Showing Average Rank of Topics as Computed from Score-Slips. Teaching Branch.

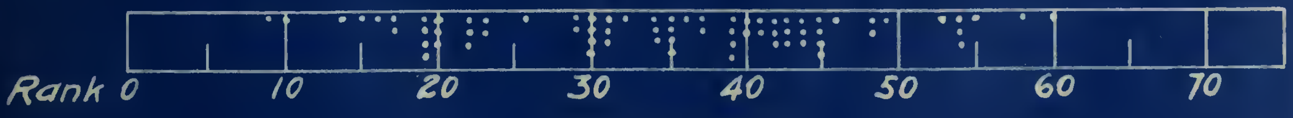
SERIES 1000					
Topic	Rank	Topic	Rank	Topic	Rank
1001	22	1026	45	1051	16
2	43	27	30	52	14
3	31	28	19	53	30
4	45	29	20	54	22
5	43	1030	36	55	20
6	39	31	46	56	29
7	41	32	10	57	34
8	42	33	35	58	19
9	31	34	23	59	17
1010	34	35	44	1060	23
11	40	36	37	61	42
12	58	37	54	62	17
13	30	38	35	63	19
14	31	39	15	64	20
15	44	1040	55	65	40
16	39	41	34	66	22
17	29	42	35	67	42
18	35	43	39	68	45
19	37	44	19	69	48
1020	43	45	60	1070	
21	35	46	54		
22	26	47	48		
23	9	48	54		
24	39	49	49		
25	45	1050	32		

SERIES 2000					
Topic	Rank	Topic	Rank	Topic	Rank
2001	43	2026	58	2051	51
2	37	27	28	52	50
3	38	28	16	53	40
4	22	29	40	54	33
5	59	2030	8	55	30
6	62	31	45	56	22
7	33	32	23	57	50
8	24	33	23	58	41
9	49	34	27	59	34
2010	23	35	19	2060	51
11	33	36	43	61	54
12	20	37	40	62	53
13		38	35	63	38
14	44	39	29	64	36
15	24	2040	34	65	30
16	40	41	36	66	28
17	22	42	42	67	46
18	21	43	36	68	21
19	23	44	47	69	22
2020	43	45	52	2070	43
21	13	46	36	71	16
22	41	47	22		
23	48	48	12		
24	41	49	58		
25	34	2050	38		

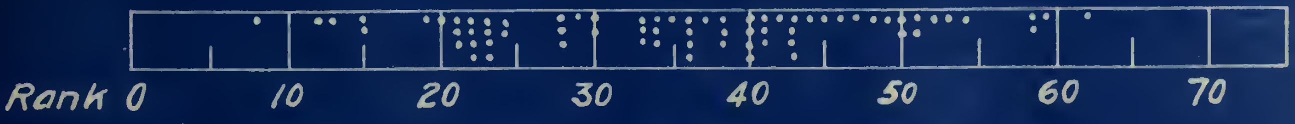
DIAGRAM II.

Showing Distribution of Data in Table II

SERIES 1000



SERIES 2000



and others whose practice had been so varied as not to justify inclusion in a distinct branch.

4. AVERAGE RANK OF TOPICS: From these record slips described and shown above, an average rank was computed for each topic. Table I shows these average rankings of topics by all except teachers. This table reads as follows: for the 1000 series, topic 1001 was given an average rank of 31, topic 1002 an average rank of 45, etc. Diagram I shows the distribution of the rankings given in Table I.

Table II and Diagram II show similar data for teachers only.

The diagrams show the interval between the ranks given to topics in different ranges of the series. Thus it is seen in Diagram I in the 1000 series, the rankings are closely grouped for the numbers from 30 to 35, whereas in the 2000 series we find a more uniform distribution through-out the range of the scale.

5. RANK ORDER OF TOPICS: By the use of the average ranks described above, the topics were put in a rank order for each of the branches and numbered 1, 2, 3, etc., from the most to the least important topic.

The above procedure can best be made clear by the use of an example. Consider the two arrays A and B, as shown below. The topics a, b, c, d, and e, have been submitted to a number of judges for comparison. The average ranks which the topics received are shown under A to be 3.2 for a, 4.7 for b, etc. Therefore, when these topics are arranged in a rank order of importance as shown under B, obviously c is given first place, d is given second place, etc. until b is given last place.

A

TOPIC	RANK
a	3.2
b	4.7
c	1.6
d	2.8
e	4.4

B

TOPIC	RANK
c	1
d	2
a	3
e	4
b	5

According to this procedure then each topic number in this study has two rank units; one as shown under A, and the other as shown under B. Reference to these different units will be made in the following pages by the use of the letters (A) or (B) to denote that unit to which reference is made.

It may be noticed that the rank orders, (B) in tables III, IV, V, and VI, (pp 19-22) are somewhat different from the arrangement that would be expected from the average ranks (A) given in tables I and II. This condition results from weighting the rank averages (A) according to the average deviations from the mean of the individual scores. In other words, if two topics have the same, or nearly the same average rank, (A) that one will be given a higher ranking (B), which has the lowest average deviation.

The results of these computations and rankings are shown in Tables III to VI. Tables III and IV. show results for series 1000, and Tables V and VI. show the similar results for series 2000. Table III reads; topic 1001 was given a rank of 30 by 11 railway engineers, a rank of 39 by 16 city engineers, a rank of 27 by 14 highway engineers, a rank of 22 by 14, drainage engineers, a rank of 28 by 28 miscellaneous engineers, a rank of 13 by 18 teachers, and a rank of 29 by 83 engineers of all branches "except teaching." The columns of "Differences" indicate the variation in rank between each branch and the combined judgment of all engineers "except teaching." Table

IV. shows the same information arranged to compare the various "topics." This table reads as follows: first rank was given to topic 1032 by the railway engineers, to topic 1052 by the city engineers, etc.

6. EXPERIENCE RECORD: The number of years of service on which the rankings are based is summarized in Table VII. The preponderance of years of service in the various branches is indicated by the heavy numerals. A comparison between these figures and the other figures of a vertical column for a given branch of surveying indicates the amount of overlapping in the practice of the men in that branch.

TABLE No. III

Showing Rank of Topics for Various Branches of Surveying

Topic	RAILWAY		CITY		HIGHWAY		DRAINAGE		M&CL		TEACHING		ALL-EX. TEACHING
	11 MEN		16 MEN		14 MEN		14 MEN		28 MEN		18 MEN		83 MEN
	Rank	Diff	Rank	Diff	Rank	Diff	Rank	Diff	Rank	Diff	Rank	Diff	Rank
1001	30	1	39	10	27	2	22	7	28	1	13	16	29
02	60	0	63	3	60	0	57	3	59	1	54	4	60
03	23	14	49	12	34	3	27	10	44	7	27	10	37
04	64	1	61	2	65	2	63	0	62	1	59	4	63
05	07	13	34	14	04	16	42	22	18	2	52	32	20
06	50	25	20	5	15	5	33	13	17	8	41	16	25
07	20	4	13	3	12	4	35	19	10	6	43	28	16
08	19	11	03	5	09	1	03	5	08	0	44	36	08
09	04	4	08	0	10	2	18	10	05	3	25	17	08
1010	12	9	26	5	07	14	41	20	21	0	28	07	21
11	35	0	43	8	24	11	37	2	35	0	46	11	35
12	65	2	60	3	66	3	60	3	64	4	67	4	63
13	53	3	53	3	47	3	30	20	58	8	29	21	50
14	25	7	35	3	23	9	43	12	34	2	26	6	32
15	10	6	12	4	22	6	41	25	07	9	49	33	16
16	06	4	16	6	18	8	13	03	04	6	42	32	10
17	29	18	46	1	53	6	48	1	54	7	20	27	47
18	52	6	56	2	49	11	58	0	67	9	33	25	58
19	44	10	65	11	54	0	47	7	55	1	39	15	54
1020	62	1	58	3	58	3	65	4	61	0	53	8	61
21	13	2	05	6	5	6	16	5	12	1	30	19	11
22	32	12	09	11	2	18	19	1	31	11	02	18	20
23	8	11	18	1	33	12	11	8	22	3	19	0	19
24	27	8	22	3	26	7	15	4	13	6	40	21	19
25	24	11	07	6	11	2	04	9	16	3	55	42	13
26	31	7	24	0	29	5	29	5	14	10	56	32	24
27	56	11	52	7	44	1	28	17	46	1	22	23	45
28	36	12	10	14	08	16	39	13	25	1	09	15	24
29	18	3	21	6	13	2	21	6	06	9	10	5	15
1030	61	4	59	2	67	10	50	7	53	4	36	57	57
31	48	4	64	12	55	3	46	6	50	2	57	5	52
32	1	0	02	1	01	0	02	1	01	0	01	0	01
33	38	3	36	1	42	7	32	3	33	2	31	04	35
34	5	9	06	8	17	3	23	9	15	1	18	4	14
35	54	0	55	1	59	5	54	0	51	3	15	39	54
36	11	27	31	7	37	1	52	14	49	11	37	1	38
37	63	3	69	3	63	3	66	0	68	2	65	1	66
38	42	5	42	5	62	15	55	8	40	7	32	15	47
39	03	11	11	3	31	17	17	3	09	5	03	11	14
1040	58	14	37	7	41	3	49	5	38	6	64	20	44
41	39	11	32	4	19	9	38	10	19	9	51	23	28
42	41	6	50	3	56	9	56	9	48	1	36	11	47
43	26	38	14	12	06	20	31	5	20	6	39	13	20
44	14	18	28	4	46	14	40	8	32	8	09	23	32
45	69	0	68	1	69	0	69	0	69	0	69	0	69
46	66	2	67	3	64	0	67	3	60	4	65	1	64
47	22	28	48	2	57	7	61	11	57	7	62	12	50
48	51	7	57	1	61	3	64	6	56	2	67	9	58
49	47	9	51	5	52	4	59	3	63	7	63	7	56
1050	37	13	30	6	14	10	06	18	29	5	25	1	24
51	55	20	33	2	40	5	12	23	36	1	05	30	35
52	02	0	01	1	03	1	01	1	02	10	04	2	02
53	59	16	45	2	48	5	45	2	30	13	22	21	43
54	55	26	17	9	30	1	25	4	23	6	17	12	29
55	49	14	29	6	36	1	09	26	42	7	13	22	35
56	15	12	15	12	20	7	34	7	39	12	24	3	27
57	46	4	54	4	45	5	51	1	52	2	35	15	50
58	33	2	19	11	35	8	24	6	37	6	08	23	31
59	09	2	04	7	39	8	10	1	03	8	06	5	11
1060	16	1	27	10	32	15	07	10	11	6	18	1	17
61	28	12	41	1	43	3	44	4	41	1	48	8	40
62	57	8	38	11	50	1	53	4	47	2	12	37	49
63	43	20	25	2	21	2	05	18	24	1	07	16	23
64	21	10	41	10	38	7	36	5	25	6	16	15	31
65	68	6	62	0	51	11	62	0	65	3	46	16	62
66	17	9	23	3	25	1	08	18	43	17	15	11	26
67	34	4	40	10	28	2	26	4	26	4	49	19	30
68	40	11	44	15	16	13	20	9	27	2	61	32	29
69	67	0	66	1	68	1	68	1	66	1	59	8	67
1070													
AVERAGE	Diff.	7.8		5.3		6.0		7.7		4.5		15.7	

NOTE "Diff" columns give the difference between each branch and "All except Teaching"

TABLE No. IV

Showing Rank of Topics for Various Branches of Surveying

Rank	RAILWAY	CITY	HIGHWAY	DRAINAGE		M&CL	TEACHING	ALL-EX. TEACHING
	10 MEN	20 MEN	14 MEN	8 MEN		21 MEN	25 MEN	73 MEN
	Topic	Topic	Topic	Topic	~~Av.D~~	Topic	Topic	Topic
1	1032	1052	1032	1052	5	1032	1032	1032
2	52	32	22	32	9	52	22	52
3	39	08	52	08	10	59	39	08
4	09	59	05	25	12	16	52	09
5	34	21	21	63	12	09	51	16
6	16	34	43	50	10	29	59	21
7	05	25	10	60	12	15	63	59
8	23	09	28	66	12	08	58	25
9	59	22	08	55	12	34	44	34
10	1015	1028	1009	1059	17	1007	1028	1039
11	36	39	25	23	16	60	29	29
12	10	15	07	51	15	21	62	09
13	21	07	29	16	11	24	55	15
14	44	43	50	15	9	26	01	60
15	56	56	06	24	8	34	66	23
16	60	16	68	21	17	25	64	24
17	66	54	34	39	12	06	54	22
18	29	22	16	09	16	05	60	05
19	08	58	41	22	15	41	34	10
20	1007	1006	1056	1068	14	1043	1023	1043
21	64	29	63	29	9	10	17	63
22	47	24	15	01	9	23	53	26
23	03	66	14	34	11	54	27	28
24	25	26	11	58	9	63	56	50
25	14	63	66	54	13	28	50	06
26	43	10	24	67	18	67	09	66
27	24	60	01	03	24	68	14	56
28	61	44	67	27	11	01	03	41
29	17	55	26	26	7	50	10	01
30	1061	1050	1054	1013	16	1053	1013	54
31	26	36	39	43	18	22	21	68
32	22	41	60	33	9	44	33	67
33	58	51	23	06	11	33	38	64
34	67	05	03	56	19	14	18	58
35	11	14	58	07	13	11	57	44
36	28	33	55	64	14	51	42	14
37	50	40	36	11	19	58	30	11
38	33	62	64	41	7	40	36	33
39	41	01	59	28	12	56	43	51
40	1068	1067	1051	1044	15	1038	1019	1055
41	42	64	40	10	21	61	24	03
42	38	38	33	05	10	55	06	36
43	63	11	61	14	25	66	16	61
44	19	68	27	01	13	03	07	53
45	51	53	57	53	11	64	08	40
46	57	17	44	31	24	27	68	27
47	49	61	13	19	14	62	11	17
48	31	47	53	17	19	42	61	42
49	55	03	18	40	13	36	67	38
50	1006	1042	1062	1030	22	1031	1015	1062
51	48	49	65	57	16	35	41	57
52	18	27	49	36	10	57	35	47
53	13	13	17	62	19	30	05	13
54	35	57	19	35	14	17	20	31
55	54	35	31	38	7	14	02	19
56	27	18	42	42	20	48	25	35
57	62	48	47	02	22	47	26	49
58	40	20	20	18	18	13	31	30
59	53	30	35	49	17	02	69	18
60	1002	1012	1002	1012	09	1046	1004	1048
61	30	04	48	47	11	20	68	02
62	20	65	38	65	16	04	47	20
63	37	02	37	04	12	49	49	65
64	04	31	46	48	15	12	40	12
65	12	19	04	20	9	65	46	04
66	46	69	12	37	10	69	37	46
67	69	46	30	46	8	18	48	37
68	65	45	69	69	08	37	12	69
69	1045	1037	1045	1045	4	1045	1045	1045
Average	Diff.							

Note "Diff" columns give the difference between each branch and "All except Teaching"

TABLE No. V

Showing Rank of Topics for Various Branches of Surveying

	RAILWAY		CITY		HIGHWAY		DRAINAGE		MSCL		TEACHING		ALL-EX.TEACHING-
	10 MEN		20 MEN		14 MEN		8 MEN		21 MEN		25 MEN		73 MEN
TOPIC	RANK	DIFF	RANK	DIFF	RANK	DIFF	RANK	DIFF	RANK	DIFF	RANK	DIFF	RANK
2001	68	9	59	0	66	7	34	25	62	3	52	7	59
2	45	7	46	8	31	7	48	10	25	13	39	1	38
3	38	2	29	7	44	8	33	3	40	4	42	6	36
4	02	3	06	1	07	2	04	1	06	1	14	9	5
5	60	5	65	0	67	2	62	3	69	4	69	4	65
6	65	3	66	2	70	2	69	1	70	2	70	2	68
7	30	3	26	1	20	7	44	17	21	4	29	2	27
8	33	11	18	4	29	7	18	4	17	5	18	4	22
9	62	0	62	0	56	6	63	1	65	3	60	2	62
2010	06	5	13	2	18	7	16	5	10	1	15	4	11
11	34	5	32	7	52	13	39	0	42	3	33	4	39
12	20	7	07	6	13	10	20	7	13	0	07	6	13
13*													
14	47	14	28	5	27	6	25	8	38	5	55	22	33
15	27	2	25	4	39	10	30	1	27	2	20	9	29
16	29	10	36	3	36	3	43	4	47	8	45	6	39
17	05	2	03	0	01	2	07	4	03	0	11	8	03
18	22	3	27	8	16	3	14	5	14	5	08	11	19
19	24	4	22	2	17	3	21	1	19	1	16	4	20
2020	49	2	42	5	47	5	54	7	46	1	54	7	47
21	14	3	05	6	22	11	08	3	09	2	03	8	11
22	41	2	40	3	43	0	50	7	43	0	48	5	43
23	46	14	23	9	34	2	26	6	36	4	61	29	32
24	58	4	57	3	62	8	42	12	57	3	49	5	54
25	19	2	14	3	08	9	19	2	22	5	30	13	17
26	61	6	69	2	68	1	66	1	68	1	67	0	67
27	53	8	48	3	41	4	29	16	44	1	23	22	45
28	48	18	41	11	12	18	09	21	29	9	04	26	30
29	35	11	34	12	49	3	60	14	50	4	43	3	46
2030	01	1	01	1	04	2	02	0	01	1	01	1	02
31	63	13	48	2	54	4	58	8	39	11	37	7	50
32	31	9	19	3	33	11	11	11	20	2	19	3	22
33	26	7	20	1	23	4	12	7	15	4	17	2	19
34	23	1	17	5	24	2	13	9	30	8	22	0	22
35	11	1	11	1	15	3	17	5	08	4	06	6	12
36	57	3	55	1	59	5	57	3	48	6	53	1	54
37	17	9	30	4	21	5	15	11	34	8	44	18	26
38	37	3	37	3	53	13	46	6	35	5	37	3	40
39	21	8	10	3	09	4	10	3	16	3	24	11	13
2040	54	4	53	3	55	5	23	27	58	8	32	18	50
41	15	10	21	4	30	5	38	13	31	6	35	10	25
42	40	4	33	3	32	4	32	4	41	5	50	14	50
43	52	1	57	6	50	1	35	16	55	4	36	15	35
44	28	13	50	9	25	16	28	13	53	12	59	18	41
45	32	18	52	2	48	2	55	5	54	4	60	16	50
46	43	5	45	7	46	8	41	3	23	15	38	0	38
47	04	0	04	0	05	1	01	3	04	0	10	6	04
48	08	5	02	1	02	1	05	2	02	1	02	1	03
49	66	2	64	0	61	5	67	3	61	3	68	4	64
2050	44	0	43	1	38	6	37	7	51	7	40	4	44
51	36	8	44	0	40	4	45	1	49	5	56	12	44
52	67	2	68	3	64	1	61	4	64	1	62	3	65
53	64	0	67	3	63	1	52	12	67	3	48	18	64
54	10	4	16	2	10	4	24	10	12	2	28	14	14
55	13	2	12	3	11	4	22	7	18	3	27	12	15
56	03	4	08	1	06	1	06	1	07	0	12	5	07
57	51	11	35	5	37	3	47	7	37	3	26	14	40
58	39	2	49	8	42	1	59	18	24	17	47	6	41
59	56	0	60	4	60	4	36	20	59	3	31	25	56
2060	55	3	38	14	57	5	64	12	56	4	63	11	52
61	70	4	70	4	69	3	68	2	60	6	65	1	66
62	69	4	63	2	65	0	70	5	63	2	64	1	65
63	18	11	24	5	19	10	49	20	33	4	41	12	29
64	16	17	47	14	14	19	56	23	26	7	34	1	33
65	50	1	54	5	51	2	27	22	52	3	25	24	49
66	25	9	39	5	28	6	40	6	32	2	21	13	34
67	59	6	61	1	58	2	65	4	66	6	58	2	60
68	07	1	09	3	03	3	03	3	05	1	09	3	06
69	12	10	31	9	26	4	31	9	11	11	13	9	22
2070	42	7	56	7	45	4	51	2	45	4	51	2	49
71	09	17	15	11	35	9	53	27	28	2	05	21	26
AVERAGE	Diff.	5.6		3.9		4.9		8.0		4.3		8.1	

NOTE "Diff" columns give the difference between each branch and "All except Teaching"

* There is no Topic No. 13 in this series

TABLE No. VI

Showing Rank of Topics for Various Branches of Surveying

Rank	RAILWAY	CITY	HIGHWAY	DRAINAGE	MSCL	TEACHING	ALL-EX.TEACHING-
	10 MEN	20 MEN	14 MEN	8 MEN	21 MEN	25 MEN	73 MEN
	Topic	Topic	Topic	Topic	Topic	Topic	Topic
1	2030	2030	2017	2047	2030	2030	2030
2	04	48	48	30	48	48	17
3	56	17	68	68	17	21	48
4	47	47	30	04	47	28	47
5	17	21	47	48	68	71	04
6	10	04	36	56	04	35	68
7	68	12	04	17	56	12	56
8	48	56	25	21	35	18	21
9	71	68	39	28	21	68	10
10	2054	2039	2054	2039	2010	2047	2035
11	35	35	55	32	69	17	12
12	69	55	28	33	54	56	39
13	55	10	12	34	12	69	54
14	21	25	64	18	18	04	55
15	41	71	35	37	33	10	25
16	64	54	18	10	39	19	18
17	37	34	19	35	08	33	33
18	63	08	10	08	55	08	19
19	25	32	63	25	19	32	34
20	2012	2033	2007	2012	2032	2015	2008
21	39	41	37	19	07	66	32
22	18	19	21	55	25	34	69
23	34	23	33	40	46	27	41
24	19	63	34	54	58	39	37
25	66	15	44	14	02	65	71
26	33	07	69	23	64	57	07
27	15	18	14	65	15	55	15
28	44	14	66	44	71	54	63
29	16	03	08	27	28	07	28
30	2007	2037	2041	2015	2034	2025	2023
31	32	69	02	69	41	59	14
32	45	11	42	42	66	40	64
33	08	42	32	03	63	11	66
34	11	29	23	01	37	64	03
35	29	59	71	43	38	41	42
36	51	16	16	59	23	43	02
37	38	38	57	50	57	38	46
38	03	60	50	41	14	46	11
39	58	66	15	11	31	02	16
40	2042	2022	2051	2066	2003	2050	2038
41	22	28	27	46	42	63	57
42	70	20	58	24	11	03	44
43	46	50	22	16	22	29	58
44	50	51	03	07	27	37	22
45	02	46	70	51	70	16	50
46	23	02	46	38	20	53	51
47	14	64	20	57	16	58	27
48	28	27	45	02	36	22	29
49	20	58	29	63	51	24	20
50	2065	2044	2043	2022	2029	2042	2065
51	57	24	11	70	50	70	70
52	43	45	65	53	65	01	40
53	27	40	38	71	44	36	45
54	40	65	31	20	45	20	43
55	60	36	40	45	43	14	31
56	59	70	09	64	60	51	60
57	36	43	60	36	24	31	24
58	24	31	69	31	40	67	36
59	67	01	36	58	59	44	59
60	2005	2059	2059	2024	2061	2009	2001
61	26	67	49	52	49	23	67
62	09	09	24	05	01	52	09
63	31	62	53	09	62	60	49
64	53	49	52	60	52	62	53
65	06	05	62	67	09	61	52
66	49	06	05	26	67	45	05
67	52	53	01	49	53	26	62
68	01	52	26	61	26	48	61
69	62	26	61	06	05	05	26
70	2061	2061	2006	2062	2006	2006	2006
Average	Diff.						

Note "Diff" columns give the difference between each branch and "All except Teaching"

TABLE No VII

SUMMARY OF EXPERIENCE

I

For men reporting on topics relating to transit & tape Nos.1001-1069

KIND OF SURVEYING WORK	BRANCH OF SURVEYING						
	RAILWAY 11 MEN YEARS	CITY 16 MEN YEARS	HIGHWAY 14 MEN YEARS	DRAINAGE 14 MEN YEARS	MISCL. 28 MEN YEARS	TEACHING 18 MEN YEARS	TOTAL 101 MEN YEARS
1 RAILWAY SURVEYS	**110**	14	31	10	25	20	210
2 " GENERAL	**166**	**3**	61	24	13	7	274
3 CITY SURVEYS	13	**97**	27	48	104	14	303
4 " GENERAL	2	**82**	34	57	109	2	286
5 HIGHWAY SURVEYS	0	39	**60**	12	34	4	149
6 " GENERAL	0	54	**64**	16	49	2	185
7 DRAINAGE SURVEYS	1	40	15	**101**	40	2	199
8 " GENERAL	0	31	33	**162**	51	0	277
9 LAND SURVEYS	23	**64**	**26**	58	**151**	8	330
10 MISCELLANEOUS	10	56	**66**	99	**105**	22	358
11 TEACHING						**155**	155
TOTAL CALENDAR YEARS OF EXPERIENCE	159	174	195	169	383	195	*1275

II

For men reporting on topics relating to plane-table, level, etc. Nos.2001-2070

KIND OF SURVEYING WORK	BRANCH OF SURVEYING						
	RAILWAY 10 MEN YEARS	CITY 20 MEN YEARS	HIGHWAY 14 MEN YEARS	DRAINAGE 8 MEN YEARS	MISCL 21 MEN YEARS	TEACHING 25 MEN YEARS	TOTAL 98 MEN YEARS
1 RAILWAY SURVEYS	**41**	14	10	3	50	22	140
2 " GENERAL	**108**	19	17	13	33	30	190
3 CITY SURVEYS	2	**143**	9	5	138	38	385
4 " GENERAL	5	**247**	42	10	125	25	454
5 HIGHWAY SURVEYS	9	3	**46**	4	51	76	189
6 " GENERAL	10	9	**69**	10	41	4	143
7 DRAINAGE SURVEYS	1	24	12	**37**	62	12	148
8 " GENERAL	5	22	14	**36**	79	25	181
9 LAND SURVEYS	11	86	23	15	**185**	48	368
10 MISCELLANEOUS	41	54	38	20	**152**	53	338
11 TEACHING						**220**	220
TOTAL CALLENDAR YEARS OF EXPERIENCE	211	391	162	107	372	372	***1615**

Note: This total is the sum of the horizontal row of totals and is not equal to the sum of the vertical column of totals because of overlapping experience in the different branches

V. ANALYSIS OF DATA.

1. VALIDITY OF METHOD OF SCORING: It will be well in our analysis first of all, to examine the propriety of the method used in ranking the topics in the cases of those men who assembled the slips in groups only. The method used is based on the assumption that each man judged the topics in each group as being of equal importance, or as having such slight variability in importance as to make it difficult to rank the individual topics. A different assumption might be made however, that the men had quite definite opinions that the topics differed greatly in importance, but failed to make the individual rankings on account of a lack of time or inclination, or by an oversight of direction No. 3 in the letter of instruction, (p. 5). If this assumption is the true one, the method used would be seriously faulty.

To answer this question, sample topics in the 1000 series were chosen. The average ranking on these topics was taken for the 49 individuals only who had ranked the separate topics. The teacher group was excluded in this test, because the average in question is that for "all except teachers." The results of this test are shown below in table VIII.

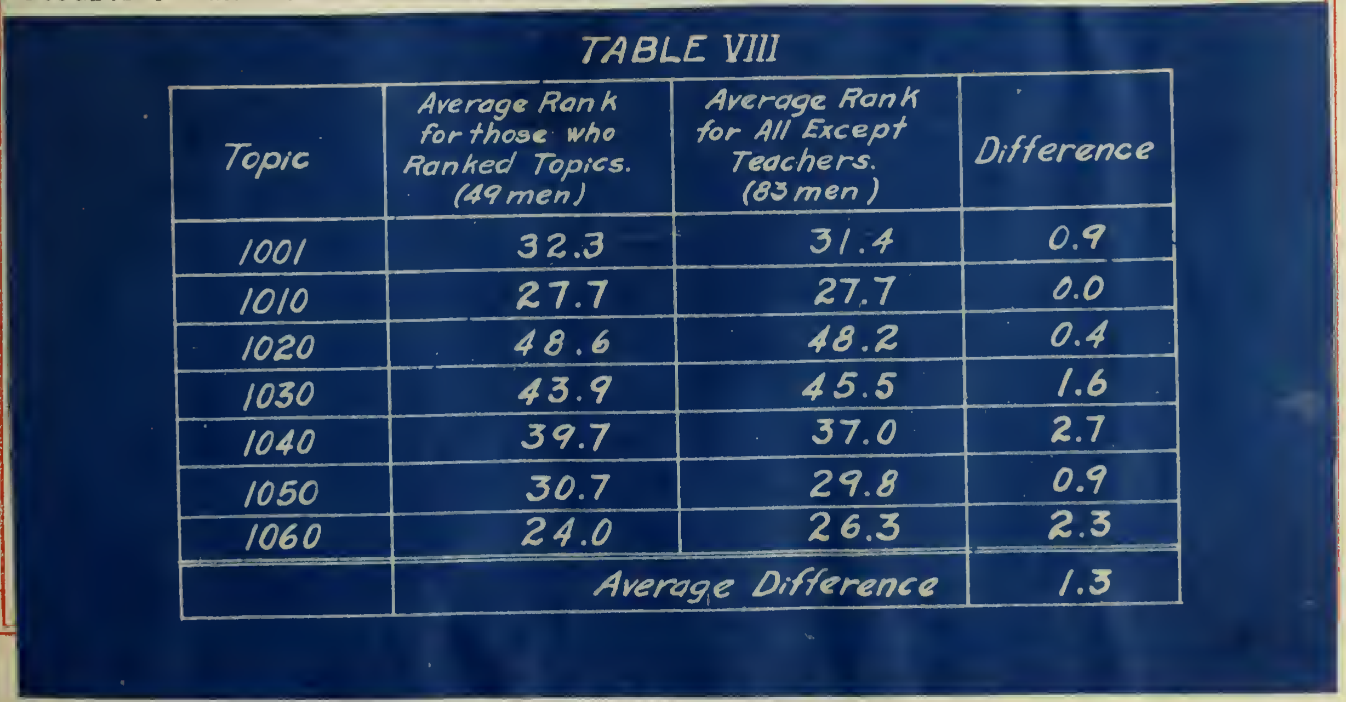


TABLE VIII

Topic	Average Rank for those who Ranked Topics. (49 men)	Average Rank for All Except Teachers. (83 men)	Difference
1001	32.3	31.4	0.9
1010	27.7	27.7	0.0
1020	48.6	48.2	0.4
1030	43.9	45.5	1.6
1040	39.7	37.0	2.7
1050	30.7	29.8	0.9
1060	24.0	26.3	2.3
	Average Difference		1.3

From these data it is seen that there is a slight difference in rank between the two groups but the significance is minimized nearly half by the increase in the probable error, namely ±.4, resulting from a reduction in the number of individuals from 83 to 49 men. This condition shows that the method used is correct well within any limits imposed by the purpose of this investigation.

2. THE AVERAGE RANK OF TOPICS: The distribution of rankings (A) in Tables I and II, also in Diagrams I and II show the important condition that the rank interval between topics is far from uniform. That is, the difference in importance between topics which rank as 30 and 31, for example, is not at all the same as the difference in importance between topics which rank as 50 and 51. The interval in the latter case is perhaps four times as great as that of the former. This fact must be kept in mind when considering the rank order arrays in Tables III to VI, for the units of difference in importance in these arrays have not the same meaning in different ranges of the tables. Therefore the use of these tables under discussion, is to indicate the significance of unit differences of rank (A).

One consequence of the above analysis must not be overlooked, namely, that the reliability of the rankings as expressed in probable error units, is measured by units (A) in Tables I and II, and Diagrams I and II. Hence, while a topic may have a given rank (B) with a probable error value of ±1.3, it can be seen that this might mean a maximum displacement in the rank order of importance of perhaps 4 or 5 places, or a minimum displacement of less than one place.

3. RELIABILITY OF RESULTS: Having established the validity of the method of treatment of the data it remains to show how reliable the results are. This will be done by considering (A) the average differences from mean

values, and (8) the probable errors of mean values.

A. AVERAGE DIFFERENCES: As regards average differences between assigned rank and the true rank of topics, it will be helpful to compare the results secured in this study with those to be expected in a chance arrangement.

The conditions attending a mere chance arrangement of these slips may be indicated briefly as follows: It is clear that in an array of 70 topics arranged by chance, any given topic (say topic No. 27) has an equal chance of being placed in any position from 1 to 70. This topic then has 70 possible "equal chance" positions in the array. Similarly every other topic has 70 possible equal-chance positions in a mere chance arrangement, hence the total number of equal-chance positions for all topics is 70 times 70 or 4900.

Let us now suppose that a true order of the topics is established, the question before us is this, what is the average difference in rank units between the place of topics in the true order, and the places of the topics in their 4900 equal-chance positions? Consider again any topic, say topic No. 27 whose place is, say No. 4, in the true order. If this topic should happen to be placed at No. 4 in a chance arrangement, the difference in rank units between the place of this topic in the true order and in the chance arrangement would be zero. If it were placed at No. 3, or No. 4, the difference would be one; if it were placed at No. 2, or No. 5, the difference would be two, etc. In this way it is possible to determine all the differences which might occur for Topic No. 27 in all the chance arrangements. Similarly, the differences for the other topics may be determined.

If now we sum the differences as computed above and divide by 4900, the number of chance arrangements, we will secure the average difference in rank units which we seek. This computation was made, and the number was found to be 23.8 units.

The average differences which these data yield are given at the bottom of Tables III and V. These show a mean difference for "all except teachers" of 5.8 units, (B). For teachers the average difference from the order established by practising engineers is 11.9. These differences are useful not only as a measure of reliability, but also in detecting exceptional topics, that is, those which are highly consistent between the various branches, as well as those which vary widely in the judgment of the different groups.

B. THE PROBABLE ERROR: This is one of the most commonly used measures of reliability and has been used in this study. We are concerned most with the precision of the rankings assigned the topics by the combined judgment of "all except teachers" and by the teachers themselves. These contrasted arrays indicate any difference in opinion between practicizing engineers and teachers as to the relative importance of topics in surveying courses. But of course any conclusions will be groundless without having established the reliability of the values in each column.

Accordingly the probable error of the rank number has been computed for random samples selected from each array and the results are shown in Table IX.

TABLE IX
Probable Error Values for Rank Numbers.

Topic	All Except Teachers			Teachers		
	Rank	r_o	r_m	Rank	r_o	r_m
1016	5	10.8	1.19	(18 men) 42	10.10	2.38
1023	15	13.0	1.43	19	9.01	2.12
1043	25	11.7	1.28			
1044	35	12.0	1.34			
1040	45	12.0	1.32	64	8.62	2.04
1019	55	9.8	1.08			
1004	65	10.7	1.17			
2044	41	12.8	1.50			
2069				(25 men) 13	8.67	1.73
2066				21	7.47	1.49
2050				40	11.90	2.38
2042				50	12.00	2.39
Average		11.6	1.30		9.68	2.07

These probable error values as is well known, have the following significance: r_o denotes the probable error of a single ranking and shows that for any topic in these series taken at random the chances are even that any person will assign it a rank within ±11.5 units from the average rank (A): r_m denotes the probable error of the average rank number, and therefore it may be said that if another group of 83 engineers ranked these topics, the chances are even that their average rank number would not differ from that determined here by more than ±1.3 units, (A).

If anyone should question the validity of the selection of these topics on the ground that they are taken, all but one, from the 1000 series, the answer would be that the average differences are greater in this series than in the other and therefore this selection makes the least favorable showing as regards the probable error values.

In the case of the teachers' rankings sample topics were chosen from both the 1000 and 2000 series because there was a considerable difference in

the number of men in the two groups and it was desirable to have each group represented.

The probable errors for these rankings are larger than for the practising engineers. But they are not as large as would be expected by virtue of the smaller numbers in the teachers' group. Roughly there are one-fourth as many teachers as practising engineers and we should expect the probable error for the former group to be twice as large as for the latter. This condition leads us to expect a probable error of ± 2.60 for the teachers whereas we find ± 2.07. This means that the teachers' rankings are somewhat more consistent than those of engineers but the final result for the former is not as reliable as that of the latter because of the larger numbers in the latter case.

We can say however from the above facts, that, the differences in rank between the teachers and "all except teachers" is a reliable index of the differences of opinion between the two groups.

4. EXHIBIT OF GROUPED TOPICS: The topics belonging to the five groups, A, B, C, D, and E in the order of importance have been assembled and are presented herewith. The membership of each group was determined first, by finding the average number of topics included in each of the five groups by the engineers and teachers; and second, by finding the rank order as shown in Tables IV and VI. and arranging the topics in the order of importance.

The groups thus exhibited include those for the four following classes:

(1) 83 engineers (1000 series); (2) 18 teachers (1000 series);

(3) 73 engineers (2000 series); (4) 25 teachers (2000 series).

This exhibit is arranged to provide a ready means of comparison between the two most important classes of men, namely, the engineers and teachers. Similar comparisons are possible between the other branches of engineering

by referring to the rank orders given in Tables IV and VI. and to the arrays of topics on pages 7 to 12.

5. SUMMARY OF EXPERIENCE: The total number of years of engineering experience on which these judgments are based is 1275 years for the 1000 series, and 1615 years for the 2000 series. These figures show an average of 14½ years experience by the men who participated. It is of course impossible to determine exactly how many calender years of surveying experienc is represented, but from an inspection of the proportion of surveying to general experience it seems safe to say that a third at least of the total calender years, represent actual surveying experience or the planning and supervision of surveys executed by subordinates. On this basis then we may say that the ranking of these topics represents 400 years surveying experience in the 1000 series and 500 years surveying experience in the 2000 series, or an average of 4½ years per man.

The proponderance of experience within a given branch of surveying is marked, but is often equalled or surpassed by the experience of the same men in the other branches combined. Hence one cannot be justified in placing much confidence in the differences in rank assigned to topics by the different branches. Such differences are more likely to be due to the small numbers involved than to a concurrance of judgments. Nevertheless, it is interesting to note such emphasis as is placed on the use of the plane-table by drainage men, etc., etc., The egregious exceptions can be readily located in the Tables III to VI.

It should be remembered in addition, that recency of experience is a potent factor in making these discriminations, which fact lends confidence to the validity of the differences shown between the different branches.

Arrangement of topics according to the judgements of 83 practising engineers, (all branches except teaching) TRANSIT & TAPE

A

On the basis of MY EXPERIENCE I judge the topics printed on the accompanying slips to be of the HIGHEST value in courses in Surveying.

1032 How to keep transit notes. (field)

1

1052 How to make the adjustments of a transit. (field)

2

1008 How to relocate lost corners.

3

1009 How to stake out a simple circular curve. (field)

4

1016 How to make a survey of a field for a deed. (field)

5

1021 How to stake out sewer lines and grades. (field)

6

1059 How to measure the angle between two intersecting lines with a transit. (field)

7

1025 How to rerun established street lines. (field)

8

1034 How to carry a transit line past an obstruction. (field)

9

1039 How to prolong a line by the method of double sights. (field)

10

1029 How to eliminate errors in tape measurements.

11

1007 How to locate established lot corners. (field)

12

1015 How to rerun an old survey from a deed.

13

1060 How to locate details with a transit and tape. (field)

14

1023 How to set a transit at a point C which shall be on a straight line between two established points A and B which are not intervisible. (field)

15

1024 How to sub-divide regular and irregular sections of land.

16

1022 The student should be given instruction in the proper handling and care of the instrument to protect it from injury. (does not refer to adjustments.)

17

1005 How to stake out a bridge. (field)

18

1010 How to stake out a vertical curve. (field)

19

Rank order is indicated at bottom of slips.

B

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of NEXT TO HIGHEST value in courses in Surveying.

1043 The student should be taught what the judicial functions of a surveyor are in connection with land surveys.

20

1063 How to compute bearings from angles and vice versa. 21

1026 How to stake out new lot lines.

22

1028 The student should be taught the sources and magnitude of errors in tape measurements.

23

1050 How to run a random line with a transit. (field) 24

1006 How to stake out a building. (field)

25

1066 How to keep notes for transit-stadia work.

26

1056 The student should be taught just what effect each instrumental error due to bad adjustments in a transit, has on the various kinds of transit work. 27

1041 How to stake out a new city sub-division. (field)

28

29

1001 How to measure a vertical angle. (field)

30

1054 The student should be taught what checks may be applied to a transit traverse. (field)

1068 How to stake out open-drainage-ditch line and grades. 31

1067 How to stake out tile-drainage-ditch line and grades.

32

1064 How to use the transit when out of adjustment so as to eliminate errors.

33

C

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of MIDDLE value in courses in Surveying.

1058 How to run a deflection angle traverse. (field)

34

1044 How to measure an angle by repetition. (field)

35

1014 The student should be made to thoroughly understand the function of the various parts of the engineer's TELESCOPE, i. e., objective lens, cross-hairs, and eye-piece.

36

1011 The student should be given a thorough drill in the details of the construction of the transit; accompanied if practicable by inspecting the various parts.

37

1033 How to measure distances, with tape only, past obstructions. (field)

38

1051 How to run an azimuth traverse. (field)

39

1055 The student should be taught what angular errors of closure may be expected in running a transit traverse.

40

1003 How to take a magnetic bearing. (field)

41

1036 The student should be taught the amount of error in transit work due to inaccurate setting over a point.

42

1061 Take slope measurements in the field and reduce to the horizontal.

43

1053 How to run an interior angle traverse. (field)

44

1040 How to Meander a stream.

45

1027 The student should be taught the sources and magnitude of the errors in stadia measurements.

46

1017 How to determine a true meridian by an observation on polaris at ELONGATION. (field)

47

1042 How to determine a true meridian by direct observation with a transit on the sun. (field)

48

D

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of NEXT TO LOWEST value in courses in Surveying.

1038 How to lay off an angle by repetition. (field)

49

1062 How to read and determine the least count of any vernier. (field)

50

1057 The student should be taught how to measure angles and erect perpendiculars with the tape. (field)

51

1047 How to determine a true meridian by an observation on polaris AT ANY TIME. (field)

52

1013 The student should be given practise in pacing distances.

53

1031 How to determine the declination of the needle. (field)

54

1019 The student should be given a working knowledge only, of the stadia formulas.

55

1035 How to survey a field with a tape only. (field)

56

1049 How to eliminate the errors due to eccentricity in the verniers of a transit.

57

1030 How to correct a bearing for change in the declination of the needle.

58

E

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of LOWEST value in courses in Surveying.

1018 How to determine the stadia constants in the field.

59

1048 The student should be taught the theory and use of the solar attachment to a transit. (field)

60

1002 How to make a compass survey of a field for area. (field) 61

1020 The student should be taught how to derive the stadia formulas.

62

1065 The student should be taught the common mistakes and errors are, in compass work.

63

1012 How to determine the probable error in sigthing a flagpole at different distances. (field)

64

1004 How to survey, with a tape only, a field with a curved boundary. (field)

65

1046 How to measure the height of a tower. (field)

66

1037 How to adjust a compass-needle and pivot point. (field)

67

1069 How to detect local attraction and to adjust a compass traverse.

68

1045 How to determine the magnifying power of any telescope. (field)

69

Arrangement of topics according to the judgements of 18 Teachers. (Transit & tape) Rank numbers at bottom of slips.

A

On the basis of MY EXPERIENCE I judge the topics printed on the accompanying slips to be of the HIGHEST value in courses in Surveying.

1032 How to keep transit notes. (field)

1

1022 The student should be given instruction in the proper handling and care of the instrument to protect it from injury. (does not refer to adjustments.)

2

1039 How to prolong a line by the method of double sights. (field)

3

1052 How to make the adjustments of a transit. (field)

4

1051 How to run an azimuth traverse. (field)

5

1059 How to measure the angle between two intersecting lines with a transit. (field)

6

1063 How to compute bearings from angles and vice versa.

7

1058 How to run a deflection angle traverse. (field)

8

1044 How to measure an angle by repetition. (field)

9

1028 The student should be taught the sources and magnitude of errors in tape measurements.

10

1029 How to eliminate errors in tape measurements.

11

1062 How to read and determine the least count of any vernier. (field)

12

1055 The student should be taught what angular errors of closure may be expected in running a transit traverse.

13

14

1001 How to measure a vertical angle. (field)

1066 How to keep notes for transit-stadia work.

15

1064 How to use the transit when out of adjustment so as to eliminate errors.

16

17

1054 The student should be taught what checks may be applied to a transit traverse. (field)

1060 How to locate details with a transit and tape. (field)

18

1034 How to carry a transit line past an obstruction. (field)

19

B

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of NEXT TO HIGHEST value in courses in Surveying.

1023 How to set a transit at a point C which shall be on a straight line between two established points A and B which are not intervisible. (field)

20

1017 How to determine a true meridian by an observation on polaris at ELONGATION. (field)

21

1053 How to run an interior angle traverse. (field)

22

1027 The student should be taught the sources and magnitude of the errors in stadia measurements.

23

24

1056 The student should be taught just what effect each instrumental error due to bad adjustments in a transit, has on the various kinds of transit work.

25

1050 How to run a random line with a transit. (field)

1009 How to stake out a simple circular curve. (field)

26

1014 The student should be made to thoroughly understand the function of the various parts of the engineer's TELESCOPE, i. e., objective lens, cross-hairs, and eye-piece.

27

28

1003 How to take a magnetic bearing. (field)

1010 How to stake out a vertical curve. (field)

29

1013 The student should be given practise in pacing distances.

30

1021 How to stake out sewer lines and grades. (field)

31

1033 How to measure distances, with tape only, past obstructions. (field)

32

1038 How to lay off an angle by repetition. (field)

33

C

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of MIDDLE value in courses in Surveying.

1018 How to determine the stadia constants in the field.

34

1057 The student should be taught how to measure angles and erect perpendiculars with the tape. (field)

35

1042 How to determine a true meridian by direct observation with a transit on the sun. (field)

36

1030 How to correct a bearing for change in the declination of the needle.

37

1036 The student should be taught the amount of error in transit work due to inaccurate setting over a point.

38

1043 The student should be taught what the judicial functions of a surveyor are in connection with land surveys.

39

1019 The student should be given a working knowledge only, of the stadia formulas.

40

1024 How to sub-divide regular and irregular sections of land.

41

1006 How to stake out a building. (field)

42

1016 How to make a survey of a field for a deed. (field)

43

44

1007 How to locate established lot corners. (field)

1008 How to relocate lost corners.

45

1065 The student should be taught the common mistakes and errors are, in compass work.

46

47

1011 The student should be given a thorough drill in the details of the construction of the transit; accompanied if practicable by inspecting the various parts.

1061 Take slope measurements in the field and reduce to the horizontal.

48

D

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of NEXT TO LOWEST value in courses in Surveying.

1067 How to stake out tile-drainage-ditch line and grades.

49

1015 How to rerun an old survey from a deed.

50

1041 How to stake out a new city sub-division. (field)

51

1035 How to survey a field with a tape only. (field)

52

1005 How to stake out a bridge. (field)

53

1020 The student should be taught how to derive the stadia formulas.

54

1002 How to make a compass survey of a field for area. (field) 55

1025 How to rerun established street lines. (field)

56

1026 How to stake out new lot lines.

57

1031 How to determine the declination of the needle. (field)

58

E

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of LOWEST value in courses in Surveying.

1069 How to detect local attraction and to adjust a compass traverse.

59

1004 How to survey, with a tape only, a field with a curved boundary.60 (field)

1068 How to stake out open-drainage-ditch line and grades.

61

1047 How to determine a true meridian by an observation on polaris AT ANY TIME. (field) 62

1049 How to eliminate the errors due to eccentricity in the verniers of a transit.

63

1040 How to Meander a stream.

64

1046 How to measure the height of a tower. (field)

65

1037 How to adjust a compass-needle and pivot point. (field)

66

1048 The student should be taught the theory and use of the solar attachment to a transit. (field) 67

1012 How to determine the probable error in sigthing a flagpole at different distances. (field) 68

1045 How to determine the magnifying power of any telescope. (field)

69

Arrangement of topics according to the judgements of 73 practising engineers, all branches except teaching. (Level, plane table, etc)

A

On the basis of MY EXPERIENCE I judge the topics printed on the accompanying slips to be of the HIGHEST value in courses in Surveying.

Rank numbers are shown at bottom of slips.

2030 How to run a line of profile-levels. (field)

1

2017 How to set grade-stakes for railway, highway, street, sewer, or sidewalk construction. (field)

2

2048 How to keep profile level notes. (field)

3

2047 How to keep cross-section notes. (field)

4

2004 How to compute cross-section areas.

5

2068 How to set slope stakes and take cross-sections for earth work. (field)

6

2056 The student should be made thoroughly familiar with the simplest methods of computing earth-work quantities.

7

2021 How to eliminate the various errors in leveling; e.g., keep the lengths of backsights and fore-sights equal. etc.

8

2010 The student should be thoroughly drilled in the various checks to be applied to computations.

9

2035 How to make the adjustments of the wye level (not peg method). (field)

10

2012 The student should be given a thorough drill in the systematic arrangement of computations.

11

2039 How to plot details on a map.

12

2054 The student should be given practise in making preliminary estimates of earth work from profiles. 13

2055 How to plot details on a profile.

14

2025 The student should be well practised in lettering.

15

2018 How to compute areas by the method of latitudes and departures.

16

2033 How to run a line of transit stadia levels. (field)

17

2019 How to plot a traverse by the method of total latitudes and departures.

18

2034 The student should be made thoroughly familiar with the details of construction of the engineer's *wye* level.

19

B

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of NEXT TO HIGHEST value in courses in Surveying.

2008 The student should be made thoroughly familiar with the degree of *accuracy* that may be expected in level circuits.

20

2032 How to keep the notes for transit-stadia levels.

21

2069 The student should understand clearly the regulations that exist between measured angles and measured distances to secure consistent accuracy in field work.

22

2041 How to estimate earth-work from contour maps.

23

2037 The student should be given a thorough understanding of the methods used in laying out the U. S. Public lands; including guide meridians, correction parallels, township exteriors and section lines.

24

2071 How to use the level when out of adjustment, so as to eliminate errors

25

2007 The student should be given practise in the computation of irregular areas; e. g., trapezoids, and areas with curved boundaries.

26

2015 The student should be made to understand how many figures are significant and should be retained in computations.

27

2063 How to use and interpret various map scales.

28

2028 How to make the adjustments of the dumpy level. (field)

29

2023 The student should be well practised in making conventional signs for maps; such as, railways, highways, trees, grass, water-lines, contours, etc.

30

2014 The student should be taught some of the common short cuts in computations.

31

2064 How to supply "missing data" in a survey; i.e., the bearing or distance of one side, etc.

32

2066 The student should be made familiar with the various checks that my be applied to plotted traverses.

33

C

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of MIDDLE value in courses in Surveying.

2003 How to determine differences in elevation by trigonometric leveling; i. e., by measured distances and a vertical angle. (field)

34

2042 The student should be given some drill in composing, arranging, and executing titles for drawings and maps.

35

2002 The student should understand clearly the effect on computed results of using the trigonometric functions of small angles.

36

2046 How to plot a traverse by the "tangent" method.

37

2011 How to compute areas by the method of co-ordinates.

38

2016 The student should be carefully advised regarding the advantages and limitations of slide-rule computations.

39

2038 The student should be taught when it is advisable to use logarithms.

40

2057 The student should be made to understand clearly the *amount* of the various errors in leveling; such as, curvature of the earth, bubble not in center of tube, etc.

41

2044 The student should be taught how the various kinds of corners in land surveys are marked.

42

2058 How to level across a wide river or ravine. (field)

43

2022 How to part-off a given area from a field.

44

2050 The student should be given practise in determining areas with the planimeter.

45

2051 The student should be taught the advantages and limitations of the planimeter.

46

2027 The student should be made thoroughly familiar with the details of construction of the engineer's *dumpy* level.

47

2029 The student should be given practise in running levels with the *hand level.*

48

D

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of NEXT TO LOWEST value in courses in Surveying.

2020 The student should determine the probable error of a single reading of a rod at various distances. (field)

49

2065 How to run a plane-table traverse. (field)

50

2070 How to determine the probable error of a series of measurements.

51

2040 How to locate contour points on the plane-table map. (field)

52

2045 How to plot a traverse by the "chord" method.

53

2043 The student should receive practise in drawing in contours on a plane-table map. (field)

54

2031 How to correct for the curvature of the earth for unequal sights in leveling.

55

2060 The student should be made familiar with the details of construction of the various kinds of level rods.

56

2036 How to run a "double rodded" line. (field)

57

2024 The student should be made familiar with the details of construction of the plane-table instrument.

58

2059 How to locate points on the plane-table by the methods of intersection and resection. (field)

59

E

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of LOWEST value in courses in Surveying.

2001 How to make the adjustments of the plane-table alidade. (field)

60

2067 How to determine the angular value of one division of a level tube. (field)

61

2009 The student should be given some practise in measuring slopes and elevations with the clinometer. (field)

62

2053 How to perform at least one plane-table solution of the three-point problem. (field)

63

2049 The student should be given practise in reproducing maps with the pantograph.

64

2052 How to perform the plane-table solution of the two-point problem. (field)

65

2005 The student should be made familiar with the construction of the aneroid barometer.

66

2062 How to read horizontal and vertical angles with a sextant. (field)

67

2061 The student should be made familiar with the principles and construction of the sextant.

68

2026 The student should be made to understand the sources and magnitude of errors in barometric leveling.

69

2006 The student should be made familiar with the constructoin of the mercurial barometer.

70

Arrangement of topics according to the judgements of 25 Teachers. (Level, plane table, computations, etc.)

A

On the basis of MY EXPERIENCE I judge the topics printed on the accompanying slips to be of the HIGHEST value in courses in Surveying.

Rank numbers are shown at bottom of slips.

2030 How to run a line of profile-levels. (field)

1

2048 How to keep profile level notes. (field)

2

2021 How to eliminate the various errors in leveling; e.g., keep the lengths of backsights and fore-sights equal. etc.

3

2028 How to make the adjustments of the dumpy level. (field)

4

2071 How to use the level when out of adjustment, so as to eliminate errors

5

2035 How to make the adjustments of the wye level (not peg method). (field)

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2068 How to set slope stakes and take cross-sections for earth work. (field)

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B

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2065 How to run a plane-table traverse. (field)

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2064 How to supply "missing data" in a survey; i.e., the bearing or distance of one side, etc.

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2041 How to estimate earth-work from contour maps.

35

2043 The student should receive practise in drawing in contours on a plane-table map. (field)

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44

2016 The student should be carefully advised regarding the advantages and limitations of slide-rule computations.

45

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46

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47

2022 How to part-off a given area from a field.

48

D

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of NEXT TO LOWEST value in courses in Surveying.

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49

2070 How to determine the probable error of a series of measurements.

50

2042 The student should be given some drill in composing, arranging, and executing titles for drawings and maps.

51

2001 How to make the adjustments of the plane-table alidade. (field)

52

2036 How to run a "double rodded" line. (field)

53

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54

2014 The student should be taught some of the common short cuts in computations.

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56

2031 How to correct for the curvature of the earth for unequal sights in leveling.

57

2067 How to determine the angular value of one division of a level tube. (field)

58

2044 The student should be taught how the various kinds of corners in land surveys are marked.

59

E

On the basis of MY EXPERIENCE I judge the topics on the accompanying slips to be of LOWEST value in courses in Surveying.

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60

2023 The student should be well practised in making conventional signs for maps; such as, railways, highways, trees, grass, water-lines, contours, etc.

61

2052 How to perform the plane-table solution of the two-point problem. (field)

62

2060 The student should be made familiar with the details of construction of the various kinds of level rods.

63

2062 How to read horizontal and vertical angles with a sextant. (field)

64

2061 The student should be made familiar with the principles and construction of the sextant.

65

2045 How to plot a traverse by the "chord" method.

66

2026 The student should be made to understand the sources and magnitude of errors in barometric leveling.

67

2049 The student should be given practise in reproducing maps with the pantograph.

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2005 The student should be made familiar with the construction of the aneroid barometer.

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2006 The student should be made familiar with the constructoin of the mercurial barometer.

70

VI. CONCLUSIONS.

The facts and data which are exhibited and analyzed in the preceeding pages have their chief significance in Tables III, IV, V, and VI; in the arrays of grouped topics pp. 30 to 42; and in Table IX showing the probable errors of the final rankings of topics. It has been shown that the rank order of topics is reliable to the extent that if other groups of equal numbers of engineers or teachers should judge the relative importance of these topics on the basis of their experience only, the chances are even that the resulting ranks of topics would not be different from these given by more than 5 places in the central portion of the series, nor by more than one or two places in the upper and lower quartiles of the series.

It should not of course, be implied that the rank orders established here are to be considered as final. Various conditions will impose important changes in the order of importance of these topics. However, the combined judgments of these engineers and teachers can hardly be ignored in determining the content of courses in surveying.

In the determination of the facts, and in making the analysis here presented, it is submitted, the purpose of this study has been accomplished.